SCIENCE

VOL. 92 FRIDAY, DECEMBER 6, 1940 No. 2397

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

MINERAL NUTRIENTS IN RELATION TO FLOWER DEVELOPMENT[1]

By Professor W. F. LOEHWING

THE STATE UNIVERSITY OF IOWA

FOR several years, the writer and his associates have investigated the role of mineral nutrients in relation to reproduction and sex expression in higher plants. From these and numerous other investigations, it is evident that the most profound metabolic and structural changes of the plant's entire life originate in the brief period between the origin of floral primordia and full bloom (Loehwing, 1938–39). Hence a detailed study, correlating chemical composition with histological structure in this particular phase of development, appeared to offer exceptional promise of valuable results, not only as to the functions of mineral nutrients in flowering but also as to their specific role in general developmental physiology.

Though interest in these investigations has centered primarily in the physiology of flowering, physiological studies obviously could not be confined to this phase alone. Only a continuous and detailed chronological inventory of the progress of events in root and shoot, from the vegetative, flowering and fruiting phase provides the requisite interpretative data. Because the most significant changes of the flowering phase are highly localized (Borthwick and Parker, 1939) the usual mass analyses of entire tops have to be supplemented with separate, sequential physico-chemical study of all formatively active zones of growth. For interpretative purposes, these data must be expressed in absolute amounts of the individual constituents as well as in the traditional terms of percentage composition. Determination of salts by actual weight is essential because of the fact that the relatively greater rate of carbohydrate and protein accumulation in plants tends to mask the critical changes in actual amounts of mineral matter. A progressively diminish-

[1] Address of the retiring president of the American Society of Plant Physiologists, Columbus, Ohio, December 28, 1939.

ing percentage of salt constituents may, for example, represent an actual gain in total amounts thereof. The divergence between percentage and absolute weight of salts is, in fact, the usual case in the growing plant. Salt content actually rises in the vegetative plant but appears in the data as a progressively lower percentage of the entire dry weight. During the reproductive phase, on the other hand, diminishing percentages of salts may frequently reflect reduction in total amounts, as becomes apparent from data discussed herein. Omission of such actual weights from many otherwise thorough studies in the literature of mineral nutrition has greatly diminished their interpretative value.

With reference to the analysis of small amounts of tissue, it may be pointed out that earlier handicaps in this connection have, in considerable measure, been removed by recent perfection of micro-analytical and histo-chemical procedures. These micro-methods not only permit analysis of the minute amounts of meristematic and floral tissues available to the physiologist but also greatly expedite analysis generally. Micro-analyses of localized areas facilitate correlation of such data with histological sections prepared from the same tissues. As a final technical detail, pot cultures of known weight in coarse sand or silica gravel permit a continuous check on growth and transpiration, and also facilitate recovery of the root system.

During the course of the experiments in a controlled greenhouse environment, certain major trends soon become evident in hemp, beans and other herbaceous annuals studied. Rapid intake of potassium and phosphorus characterizes the period of seedling growth, but are overtaken by nitrogen absorption prior to initiation of floral primordia (Demidenko and Popov, 1937). Under conditions of adequate nutrient supply, the first obvious indication of flower inception is a rather abrupt and progressive increase in the rate of transpiration, readily detectable by the amount of water necessary to maintain the cultures at approximately constant weight. Despite the transitory rise in rate of absorption, tissue analyses at this stage show that plants actually undergo a change in water balance in the direction of lower water content and higher percentage dry weight. Water loss definitely exceeds rate of supply and a trend toward progressive dryness of tops is initiated (Bakhuyzen, 1937; Gouwentak, 1929; Mothes, 1931; Smirnov, 1928). The trend toward tissue dehydration, once started, is ordinarily continuous for several weeks and sometimes even to ultimate maturity. It is interesting to note that this increase in transpiration and change in water balance frequently precedes the appearance of visible floral structures.

Reduction in water supply entails a proportional change in solute concentration of all tissue fluids (Bakhuyzen, 1937). A rise in osmotic pressure of press sap is readily demonstrable but owes its origin not only to increased concentration of mineral nutrients but also to a rather sharp rise of soluble nitrogen and carbohydrates in the sap. The change in water balance thus appears to induce hydrolysis of insoluble protein and polysaccharide reserves, a metabolic transition generally known to presage early structural modification. Rise in rate of transpiration and the subsequent hydrolysis of insoluble carbohydrates originates in restricted areas of which the shoot apices are the initial foci. Increase in tissue dry weight spreads from these apical regions to adjacent leaves. Rapidly transpiring leaves thus deplete the water supply of contiguous tissues of lower osmotic pressure. Normal translocation upward is deflected from apical zones, and salts commence to accumulate in axillary loci. Dehydration is progressive in leaves and stem until entire shoots are involved.

In the roots, the change is not immediately one of altered water balance but rather a reduction in rate of salt intake, as becomes evident from successive determinations of the total mineral matter (Potapov, 1938). The percentage drop in salt content usually noted in roots at this stage is not wholly ascribable to the rapid increase of organic materials but represents in part an actual diminution in rate of salt entry. Determinations of actual salt content rather than its percentages are extremely helpful in the immediate detection of this change in root activity. Eventually, as flowering approaches its ascendency, the water content of the root system also becomes depleted and it then parallels the progressive drying of the shoots. The root at this time lapses into a state of retarded absorption of both salts and water which tends to accentuate tissue dehydration generally throughout the plant. Other investigators have also previously observed that salt intake up to the time of flowering is approximately commensurate with rate of supply but that it then begins to fall off (Crowthers, 1934; Deleano, 1936).

As the fall in water content of roots and flowering tops becomes more pronounced, there occurs a marked redistribution of salts throughout the entire plant. Entire shoots commence to lose an appreciable proportion of their nutrient reserves (Burd, 1919; Deleano, 1936) while at the same time residual salts tend to accumulate at floral loci. Nutrient depletion of vegetative organs and later even of accessory floral parts leads to an ultimate concentration of salts in developing stamens and pistils (Combes, 1938). Relative proportions of the different ions in the stem as a whole are also materially altered. Nitrogen and phosphorus accumulate at reproductive centers in part at the expense of shoot apices.

It is interesting to note that the number of floral

primordia initiated is usually correlated with the amount of nitrogen and phosphorus in adjacent tissues (Biddulph, 1935; Cameron and Appleman, 1934; Grainger, 1938; Haas, 1935; Polster, 1938). Localized nutrient reserves thus appear especially important in early phases of flower development. In short, at the time of flowering all the nutrients, organic and inorganic, are in a state of extreme flux, which appears to be a mobilization of food reserves preparatory to the later utilization of certain compounds at reproductive centers. Similar responses with reference to concentration of organic reserves in developing fruits have been reported by other investigators (Murneek, 1932–37; Kraus and Kraybill, 1918) but actual mobilization seems to commence well in advance of fruiting proper (Bakhuyzen, 1937).

To judge from the universality and profundity of other changes which promptly follow, the original shift in internal water balance is by far the most significant event in the entire nutritional picture. Uniformity and magnitude of the drop in water content make it a reliable index to the onset of flowering. Shift in water balance, indeed, appears to resemble a trigger action which unleashes extensive subsequent changes in metabolism of roots as well as shoots.

The increase in osmotic pressure of tissue fluids in the tops gradually extends to the roots and is attributable in part to the translocation there of salts from the tops as reproduction progresses. Though there is a rise in *percentage* of salts in the root and a rise of salt concentration in root sap, the *absolute amount* of inorganic ions is usually less on a true weight basis. These facts lead, then, to the obvious conclusion that the salt content of the entire plant is often less during the reproductive than during the previous vegetative stage. This implies excretion of nutrients from root to soil (Ackromeiko, 1932–36; Bakhuyzen, 1937; Burd, 1919; Loehwing, 1937; E. C. Miller, 1939). The phenomenon of nutrient excretion is especially evident in plants grown at high nutrient levels (Luttkus and Boetticher, 1939). But even in plants under conditions of inadequate feeding there is also evidence of similar accumulation of salts in the roots at the expense of tops. The element particularly involved in excretion is potassium with lesser amounts of nitrogen and phosphorus (Deleano, 1936; Ackromeiko, 1936). The speed and apparent ease with which potassium moves from tops of high to roots of lower osmotic pressure during the period of disturbed water balance, suggests a poising function of potassium in avoidance of injurious extremes of both osmotic pressure and nutrient disbalance among the mineral salts in the aggregate.

The metabolic readjustment to this increase in solute concentration of tissue fluids is extremely far-reaching. For example, plants at this stage are very conspicuously sensitive to drought, a fact noted by other workers in a wide variety of plants (Saskin, 1938; Bakhuyzen, 1937; Stevanovskii, 1936; Maximov, 1929). Drought sensitivity during flowering is presumably interpretable as a definite increase in foliar permeability. If behavior of this sort is demonstrable in experimental plants under conditions of uniform water supply, the effects of water disbalance at the flowering stage must be even more pronounced in crops under the natural field conditions of water scarcity during midsummer. The entire literature on mineral nutrition is replete with evidence of water shortage during the flowering phase of crop plants, and it is difficult indeed to understand that its physiological significance has not been generally recognized.

The functional as apart from the formative aspects of flowering, then, seem to involve the following sequence of events, namely, increased transpiration and its resultant upset of internal water balance in the shoot; osmotic and solute increments of the sap; and finally redistribution of nutrient elements throughout the entire plant, often involving some elimination of salts from the root.

With reference to mineral nutrients, the net effect of these changes during flowering would be to make the shoot, temporarily at least, largely dependent upon its own residual supply of salts rather than upon any rapid upward flow thereof from the roots (Crowthers, 1934). The assumption of what amounts to a partial, functional separation of root and shoot derives support not only from the above described changes in nutrient distribution and drought sensitivity but also from the vascular alterations known to be associated with flowering. The important researches of Roberts (1939) and associates (Struckmeyer, 1938; Wilton, 1936) on reduction in cambial activity and the resultant restriction in phloem clearly indicate that the flowering plant confronts serious problems in translocation (Gill, 1933; Liehr, 1927; Whyte, 1929). Wisconsin investigators (Roberts, 1939) report that locally applied low temperatures in the form of a girdle about the stem also act as an effective means of flower production, an observation which adduces additional evidence that reproduction is correlated with modified translocation. Similar reproductive responses have been induced by general low temperature treatment (Thompson, 1936–38) and by constrictions about stems (Roberts, 1939). Further corroboration of the conclusion that impaired conduction disposes to flowering is found in the recent painstaking work of Borman (1939) on the rooting of flowering cuttings. He finds, for instance, that cuttings of *Mirabilis viridis* taken in full bloom continue to flower until they take root, after which they initiate vegetative growth. Some of Borman's other data on rooting of cuttings also suggest a connection between flowering and restricted transport of nutrients.

Any stimulus which renews vascular development, rapid absorption and mass flow of nutrients re-initiates vegetative growth. This is shown in experiments on rejuvenation by reversal of the photoperiod. Plants in blossom can usually be induced to renew growth by shifting to a vegetative photoperiod. Within two days after such alteration in the light period, there occurs a drop in transpiration, followed by increased intake of water and vegetative proliferation at stem apices.

Mobilization of organic and inorganic feed reserves in the manner described has previously been associated by other investigators (Murneek, 1925–37) with the process of fruit development. In the speaker's opinion, there is no actual discrepancy in the two points of view, nor is there any doubt about the intense food demands of enlarging fruits in heavily fruited species. Our own data merely indicate that mobilization of reserves *begins* with flower formation rather than with fruiting. This is apparently preparation for the immediate and large respiratory demands of flowering itself as well as for the heavier nutrient demands of fruit enlargement. High rates of respiration during the flowering phase temporarily deplete carbohydrate reserves, yet this very fact makes the concentration of salts at floral loci especially noticeable. On the experimental side, it is easy to miss nutrient changes which originate during flower inception because this phase is brief and soon overshadowed by events of the fruiting phase.

It is interesting to observe that as fruiting attains ascendency, there again occurs a gradual rise in rate of water absorption and the entire picture of water relations is one of better balance. Transpiration gradually subsides with onset of fruiting but ordinarily does not fall to the vegetative level. Simultaneous with the improved water balance of the fruiting phase, the flow of inorganic nutrients from root to top is accelerated. From the nutrient standpoint, conditions in the fruiting plant somewhat resemble those of the original vegetative phase except that fruits instead of vegetative structures now serve as centers of deposition. Fruit development may, in fact, be the actual inception of vegetative nutrition by the young embryos which merely employ the old sporophyte instead of the soil as a substrate.

There still remains, of course, the problem of nutrients in relation to sexual differentiation; namely, as to the factors responsible for differentiation of pistils and stamens. In this connection mineral nutrients are probably less specific in their influence than certain morphogenic inductors, like the so-called flowering hormones (Cailachian, 1937; Kiesel and Pachewitsch, 1938; Riede, 1937; Savelli, 1937) which may be a carotinoid (Murneek, 1934). But certain inorganic ions are not without effect even in this connection, as evidenced from our data on sex differentiation in dioecious forms. High nitrogen supply results in a pure stand of pistillate hemp plants, while low nitrogen produces entirely staminate plants (Tibeau, 1936). The results are not attributable to selective mortality.

Physiological studies on sex expression in hermaphroditic species are more difficult than in dioecious forms because of the close proximity of the two sex organs. This complicates disentanglement of the staminate and pistillate processes which precede the actual appearance of the sex parts themselves. Combes (1936) has recently shown that accessory floral parts supply mineral nutrients first to the developing stamen and later to the pistil (Mason and Phillis, 1936). High nitrogen content is in general associated with pistil differentiation in both dioecious and monoecious species (Howlett, 1936; Loehwing, 1933; Tibeau, 1936) while low soluble ash favors stamen inception (Stanfield, 1937).

In summary, the sequence of physiological events antecedent to and concurrent with flowering comprises, first, the change in internal water balance, followed in turn by altered translocation and redistribution of nutrients. Precise knowledge of the pattern of salt distribution aids in identification of phosphorus and nitrogen as the inorganic ions most closely associated with early phases of the transition from the vegetative to the reproductive phase. Amino compounds seem to be especially specific in their effects on sex processes, and studies are now under way to identify them and determine the precise role of commonly occurring amino acids.

PETROLEUM AND NATIONAL DEFENSE[1]

By Dr. GUSTAV EGLOFF

DIRECTOR OF RESEARCH, UNIVERSAL OIL PRODUCTS COMPANY, CHICAGO, ILLINOIS

THE United States has the largest and most efficient army of fully trained petroleum hydrocarbons of any nation in the world or any combination of nations, available for immediate service to meet any need, either peacetime or in the national defense.

With 61 per cent. of the world's total oil production occurring within this country, American technology has developed the world's most effective and, in

[1] Address delivered at Purdue University, October 31, 1940.

many instances, only methods for maneuvering this army of petroleum hydrocarbons into the patterns which result in motor fuels and other products of a quality to more than meet the exacting requirements of high-powered engines of the most advanced design. It has applied these methods for designing petroleum molecules for quality fuels in peacetime on a scale which is not remotely approached by all other nations combined.

The United States has almost all the world's production of 100 and higher octane aviation gasoline, which supplies enormous increases in maneuverability, cruising range, lifting power and speed to airplanes with engines designed to utilize the properties of this fuel. Such production of 100 octane gasoline as there is outside the United States is by American processes, and is almost entirely concentrated within the British Empire.

The Americas control over 1.5 billion barrels out of the 2 billion yearly crude oil production—over three times as much as the rest of the world. The United States alone produces over one and one-half times as much or sixty-one per cent. of the world's total. The oil industry of the United States is ready now to produce any volume of oil for any purpose required—whether for peace or national defense. There will be no need for the gasolineless Sundays that occurred during World War No. 1. Crude oil production and refining facilities can be stepped up rapidly whenever the demand is present. Within its own borders the United States has more than enough natural gas and crude oil to produce all the aviation gasoline, motor fuels and lubricating oils for our every need. That strategic material, rubber, can be produced by the oil industry in any quantities required; this also holds true for the explosive, TNT.

Present indications are that the Axis powers might develop a real shortage of oil and lubricants for industrial, air, army and navy requirements in event of a long war. This shortage will be based upon lack of crude oil and substitute fuels, whether from hydrogenation of coal, carbon monoxide, liquefied hydrocarbon gases and gas produced from wood, coal, lignite and coke, directly on the motor vehicle. The volume of oil produced within European countries has not been sufficient to cover the amounts consumed even in peacetime.

Germany's crude oil and substitute fuels show an estimated yearly production of 49 million barrels. This represents less than two and one-half per cent. of the world's crude oil. Oil consumption in Germany and Czecho-Slovakia in 1938 amounted to 60 million barrels, a figure which in spite of curtailment of all civilian uses of petroleum can not cover the military requirements on a 1940 wartime basis. Although large volumes of stored petroleum went to the German army by the capture of a number of countries, it is difficult to estimate the amount actually falling into their hands. This is due to the unknown factor of sabotage of oil supplies by retreating armies. Air raid destruction and damage of synthetic oil plants and storage now going on has cut fuel supplies.

Italy's oil from Albania and synthetic fuels is about two million barrels a year or less than one tenth of one per cent. of the world's crude oil.

The total oil production of Austria, Hungary, Poland, France, Rumania and Czecho-Slovakia amounts to 58 million barrels or about three per cent. of the world's total.

Crude oil production in Russia is about 220 million barrels or ten per cent. of the world's total, which is probably lower than her internal demands due to industrial, army and aviation expansion.

Japan's oil production is about one tenth of one per cent. of the world's total, whereas the Dutch East Indies yields about three and one-half per cent.

England's empire has oil sources of over 150 million barrels a year from Iran, Iraq, Bahrein, Burma, Trinidad and Canada, and may draw from the 205 million of Venezuela, 39 million of Mexico and 22 million of Colombia.

Accessible to Great Britain as long as her maritime power endures are the oil fields of Central and South America, which have a yearly production of 300 million barrels or fifteen per cent. of the world's total.

The United States has an inexhaustible potential supply of natural gas, crude petroleum, coal and oil shale for the manufacture of any conceivable quantity of oil products for national defense or peacetime requirement.

No other country produces the quantities or qualities of such petroleum products as motor fuels for airplanes, pleasure cars, motor buses, tanks and tractors. Aviation gasolines of 100 and higher octane rating, solely a product of research in the United States, that give airplane maneuverability, speed of climb, shortness of take-off and dead weight lifting power are also available from this source.

Superb lubricating oils are produced for every human requirement, whether it be for lubricating fine watches or spindles, heavy duty machines or 2,000 horsepower airplane engines, four of which power the latest flying fortresses. These newer lubricants developed in the United States are not only selectively refined, but contain added chemicals which impart high film strength and give greater oxidation and sludge resistance.

Diesel oils for low- to high-speed engines are produced to fit any need of tanks, buses, trains and

submarines. With the development of 100 octane motor fuels, the gasoline engine has equalled the efficiency of the best Diesels of to-day with the added advantage of greater maneuverability in airplanes and other motor vehicles.

All battleships, cruisers, transports and airplane carriers use fuel oil and lubricating oil in huge quantities, but there are no demands, even if far in excess of present requirements made upon the oil industry, which can not be fulfilled.

Petroleum gases have also come into their own in the past few years, making possible such products of military importance as alkylates, isooctane and neohexane motor fuels, which are vitally necessary as fuels for airplanes.

Synthetic rubber from petroleum is manufactured from benzene and ethylene yielding styrene, and by dehydrogenation of butane forming butadiene. The synthetic rubber has about 30 per cent. greater wearing quality and strength than natural rubber in tires now on the market. There are over 200 billion pounds of synthetic rubber potentially available from petroleum yearly.

The lower boiling hydrocarbons in petroleum from Pennsylvania, Mid-Continent, Michigan, East Texas and Kettleman Hills, California, are mostly straight-chain paraffins. Upon catalytic treatment at 932° F. and at atmospheric pressure these hydrocarbons can be converted into benzene, toluene and the xylenes. These compounds are basic materials for such high explosives as picric acid, TNT and trinitroxylenes. The quantities potentially available from the petroleum industry are at the rate of 85 billion pounds yearly. Commercial units to produce toluene and TNT from petroleum are now being installed.

In either war or peace, the United States of America has within its boundaries more than enough crude oil for complete self-sufficiency and could, if necessary, supply the petroleum products for the world's needs.

SCIENTIFIC EVENTS

UNIVERSITY COLLEGE, LONDON[1]

. . . HERE I regret to have to tell you that the college suffered badly, first by a land-mine and then by fire. The land-mine carried away the Great Hall and did a great deal of damage to roofs, windows, etc., in the main buildings of the college (apart from Foster Court which was practically untouched). The medical sciences building lost practically all its windows and the big physiology laboratory at the top of the building has lost most of its roof. A few days later there was a fire (due to incendiary bombs) which destroyed the libraries north of the main library and Flaxman Gallery, including a good many of the arts libraries and a large part of the physical sciences library. All this has meant that any attempt to carry on the teaching of medical sciences in our own building during this session is impossible. I am glad to say, however, that we have been able to make arrangements whereby the students in the faculty of medical sciences will be working in a large building near Leatherhead, which had laboratories which could be adapted for the purposes of the faculty. The staff have been indefatigable in making these arrangements and I have every hope that the continuity of our medical teaching, possibly even of some of our medical research, may be secured. Arrangements are being made to put as much of the equipment as is possible in various places of comparative safety. With regard to the rest of the college, we are removing the remainder of the library to a place of comparative safety, and have managed to redistribute the students among various colleges and universities.

[1] Excerpt from letter of the 11th of October, 1940, to Dr. Alan Gregg, from Principal Allen Mawer, of the University College, London, England.

The main disasters happened two or three weeks ago, and I should have written to you long since, but it was only yesterday that the Ministry of Information released the facts. . . .

At the present time, one can do little more than carry on, but we look ahead to the time when this nightmare is over and we can start to build up our work again.

DAMAGE TO SCIENTIFIC INSTITUTIONS IN LONDON

INFORMATION has recently been received from London of the bombing of the British Museum (Natural History) at South Kensington. The museum has been hit by both high explosives and incendiary bombs. The most serious damage was caused by an incendiary bomb which fell on the roof of the east wing and penetrated to the foreign herbarium of the Botany Department. A large number of plant specimens were destroyed, and many thousands of herbarium sheets were badly damaged by fire and water. It is understood that the department of entomology was also damaged. American botanists are of the opinion that many unrecognized type specimens of American and other plants were stored in the Foreign Herbarium, though a great deal of the most valuable material from several departments of the museum had been removed from London last spring. The near-by Victoria and Albert Museum has also been hit. Neither building is close to any military objective.

The London *Times* writes as follows: "The library of the Royal Society of Medicine is the finest medical library in Europe. It contains 150,000 medical volumes and provides an information service to the fel-

lows of the society wherever they may be. It has been giving valuable service to doctors in the fighting forces, oversea and at home, since the outbreak of war, and supplying information to men in the emergency medical services as well as in every department of medical life in this country. These services have been rendered in difficult circumstances, as the society lives almost entirely on the subscription income received from its fellows. This income has seriously diminished since the outbreak of war, but the society has nevertheless carried on with its important work. Officers returning from the beaches of Dunkirk have reported to the secretary that information received from the library was invaluable, and that they regretted having had to abandon books, bibliographies and photostatic reproductions in the face of the advancing enemy. The Rockefeller Foundation, learning of the society's service and of its plight, has generously given £1,000 to enable its headquarters at 1, Wimpole Street, to spread the target which it offers to bombing aeroplanes. With this gift it is being arranged to remove a large number of irreplaceable volumes to a suitable place in the country, where they will be easily available to inquirers for information."

EMERGENCY COURSES TO TRAIN ENGINEERS AND TECHNICIANS

EMERGENCY courses to train engineers and technicians needed in the nation's defense industries will be offered soon in a cooperative program sponsored by Harvard University, the Massachusetts Institute of Technology, Northeastern University and Tufts College.

The proposed program comprises full-time day courses, as well as evening courses of college grade for men who are employed. Organized to comply with the engineering defense training program of the United States Office of Education, this plan, which has been presented for formal approval, is part of a project supported by the government for specialized training in fields essential to national defense. The courses will be offered if there is sufficient demand to satisfy the requirements of the United States Commissioner of Education, and will be given without charge to the students for tuition.

The other engineering schools in the Northeastern regional district, which includes Maine, New Hampshire and Vermont, as well as Massachusetts, are preparing to offer similar intensive courses. These programs are being planned by the individual colleges, which have the cooperation of the regional adviser on engineering defense training, Dean Edward L. Moreland, of the Massachusetts Institute of Technology.

The joint program of the four greater Boston institutions was arranged to avoid duplication of courses and to assure the most effective utilization of the special teaching and laboratory resources of each. The committee in charge of the project, which is expected to train approximately 1,000 students, includes Dean Harald M. Westergaard, of the Harvard Graduate School of Engineering; Professor Raymond D. Douglass, of the Massachusetts Institute of Technology; Dean William C. White, of the College of Engineering of Northeastern University, and Dean Harry P. Burden, of the Tufts School of Engineering. None of the courses conflicts with or replaces regular evening courses now being offered by such agencies as the State University Extension Service, the Lincoln Institute, the Lowell Institute School or the university extension courses of Tufts College.

All courses in this program are of collegiate grade and in general the requirements for admission include at least three years in an accredited engineering school or its equivalent. In some instances two years in an evening engineering school plus practical experience may be considered sufficient preparation, and in certain cases other preparation may be acceptable. Certain highly specialized courses will require engineering degrees.

Application for detailed information on all courses to be given at the participating colleges in the Boston area should be made immediately, and by mail only, to the Engineering Defense Training Bureau, Room 7–102, Massachusetts Institute of Technology, Cambridge.

THE HOSPITAL OF THE MEDICAL COLLEGE OF VIRGINIA

DEDICATION of the new six hundred bed hospital at the Medical College of Virginia, Richmond, took place on December 5, Founders' Day. Among those participating were Governor James H. Price; Colonel E. W. Clark, Commissioner of Public Works, Public Works Administration; Dr. Walter L. Bierring, past president, American Medical Association; Dr. Walter B. Martin, president of the Medical Society of Virginia; Dr. H. E. Jordan, dean, department of medicine, University of Virginia; M. Haskins Coleman, Jr., secretary, Richmond Hospital Council, and Dr. Lewis E. Jarrett, director of the hospital division, Medical College of Virginia. Beginning at two o'clock in the afternoon the new hospital was opened for inspection to the general public, and on Tuesday night, December 3, a reception and hospital open house was observed at the hospital for the local medical profession and specially invited guests.

The new hospital, completed at a cost of approximately $2,500,000, with equipment, provides for two new services, neuropsychiatry and contagious diseases, enlarged facilities for physical therapy and many other activities, including ample provision for teaching. It is built in the form of a Maltese cross with the various utility services in the center of the cross, the wings themselves being used for the housing of patients. By

this arrangement wards have exposure on both sides and each room has an outside exposure. It is completely air conditioned.

Acoustical treatment has been applied to all corridors, lobbies, utility rooms, diet kitchen and in any other place where excessive noise may be a disturbing factor.

The entire building is being wired for radio reception. A central unit will control reception and has a four-channel outlet to each part of the building. For the present, however, these channels are only being wired for two programs. The other two can be wired later at nominal cost. In the wards there are speakers attached to the ceiling, one speaker for each eight beds. Individual rooms will have individual speakers. The volume of the radio can be controlled at the central receiving station and each individual unit can be controlled in the wing itself.

THE MEETING OF MATHEMATICIANS AT BATON ROUGE

THE forty-seventh annual meeting of the American Mathematical Society will be held at the Louisiana State University, Baton Rouge, La., from December 30 to January 1, in conjunction with meetings of the Mathematical Association of America and the National Council of Teachers of Mathematics.

The sessions of the society will begin on Monday afternoon and will continue through Wednesday afternoon. The regular sessions of the Mathematical Association will be held on Thursday morning and afternoon. A joint session of the Mathematical Association and the National Council is scheduled for Wednesday morning. Other sessions of the National Council will be held on Monday and Tuesday.

The Board of Trustees will meet at 6 P.M. on Monday and the Council of the Society will meet at 8 P.M.

The annual business meeting and election of officers will be held on Tuesday evening. Following this, Professor G. C. Evans will deliver the retiring presidential address on "Surfaces of Minimum Capacity."

By invitation of the program committee, Professor Saunders MacLane and Dr. Leo Zippin will deliver addresses. Professor MacLane's title is "Extensions of Groups" and Dr. Zippin's, "Topology of Rigid Motions."

An excursion to St. Francisville and its environs to visit some of the old colonial residences is planned for Tuesday afternoon. Other alternative excursions may be planned later.

A joint dinner of the three mathematical organizations is planned for Wednesday evening.

AWARD OF THE MEDALS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

DR. CHARLES F. KETTERING, vice-president and director of General Motors Corporation and general director of General Motors Research Laboratories, received the American Society of Mechanical Engineers Medal, presented annually for distinguished service in engineering and science, on December 4. The presentation was made by Warren H. McBryde, national president of the society, at the annual dinner and honors night.

The award has been made to Dr. Kettering in recognition of his outstanding achievements as engineer, inventor and manufacturer. He invented and perfected the automobile self-starter and the Delco lighting system for farms and as a portable source of power. He is also largely responsible for many engine improvements and, most recently, for the development of improved Diesel engines for trains and ships. Dr. Kettering is patentee or co-patentee of about 140 inventions.

Edwin H. Armstrong, professor of electrical engineering at Columbia University and pioneer in the field of "frequency modulation" and other radio circuits, received the Holley Medal.

Dr. Armstrong has long been a leader in the development of radio communication. He was first to make practical use of the three-electrode tube for generating continuous electric waves which make radio broadcasting feasible; and invented the widely used superheterodyne receiving circuit. His most recent work has been in the new field of his own invention, FM or "frequency modulation" radio broadcasting, which has made practicable the avoiding of static nuisances, as well as decreasing danger due to lightning.

The Holley Medal is presented periodically for distinguished service in engineering and science. It is named for the late Alexander Lyman Holley, chairman of the meeting on February 16, 1880, at which preliminary plans for the organization of the society were discussed. It was endowed by George I. Rockwood, who recently retired as president of the Rockwood Sprinkler Company of Massachusetts.

The Melville Medal for original engineering work was presented to Carl A. W. Brandt, chief engineer of the Superheater Company, New York, for his paper on "The Locomotive Boiler."

Mr. Brandt was born in Stockholm in 1881, studied mechanical engineering at the Technical College there, and obtained his early engineering experience with the Swedish Government Railways and the Sweden Atlas Locomotive Works. He was with the New York Central Lines from 1902 to 1916, becoming mechanical engineer and master mechanic of the Cleveland, Cincinnati, Chicago and St. Louis Railway in 1910. He joined the Superheater Company as chief engineer in 1916, where he is now in charge of the development and design of locomotive equipment, including superheaters and feedwater heaters, in addition to similar apparatus for stationary power plants.

SCIENTIFIC NOTES AND NEWS

THE William du Bois Duddell Memorial Medal of the London Physical Society has been awarded to Dr. Ernest O. Lawrence, professor of physics at the University of California at Berkeley and director of the Radiation Laboratory. It is expected that the presentation will be made on December 27 by Lord Lothian, British ambassador to the United States, at the meeting of the American Physical Society, which will be held at Philadelphia in conjunction with the American Association for the Advancement of Science.

AT a special convocation on November 24, Columbia University conferred four honorary degrees. These included the doctorate of science conferred on Dr. Karl T. Compton, president of the Massachusetts Institute of Technology. The degree was to have been presented to Dr. Compton at commencement last June, but he was unable to be in New York at that time.

DR. TORALD SOLLMAN, dean of the School of Medicine of Western Reserve University, and Dr. J. M. T. Finney, professor emeritus of surgery of the Johns Hopkins University, received the degree of merit of Nu Sigma Nu at a dinner given on November 23, which closed the annual convention in Detroit of the fraternity.

THE Remington Medal, awarded annually by the New York branch of the American Pharmaceutical Association for constructive work in the interest of American pharmacy, was presented to Dr. Robert L. Swain, editor of *Drug Topics* and *Drug Trade News*, at a testimonial dinner given at the Hotel Pennsylvania, New York, on November 28.

THE Gedge Prize of the University of Cambridge has been divided equally between Dr. D. A. Webb and D. K. Hill, both of Trinity College, for research in physiology.

NOMINATIONS for officers of the American Electrochemical Society include: for president, Raymond R. Ridgway, research engineer with the Norton Company of Chippewa, Canada; Frank E. Lathe, technical assistant to the president of the National Research Council of Canada, and A. F. Grant Cadenhead, director of plant research with Shawinigan Chemicals, Ltd.; for vice-presidents, Albert E. R. Westman, director of chemical research at the Ontario Research Foundation; Sherlock Swann, Jr., professor of chemistry at the University of Illinois; John W. Marden, assistant director of research of the Westinghouse Lamp Division, Bloomfield, N. J.; Malcolm Dole, professor of physical chemistry at Northwestern University, and Frank W. Brooke, consulting engineer.

DR. HENRY E. MELENEY, associate professor of preventive medicine and public health at Vanderbilt University, has been appointed Hermann M. Biggs professor of preventive medicine and director of the laboratories of the New York University Medical School. He succeeds the late Dr. William H. Park.

DR. ELMO N. STEVENSON, of the Eastern Oregon College of Education at La Grande, has been appointed professor of science education at Oregon State College, Corvallis.

DR. JACOB LEVITT, formerly research fellow of the Royal Society of Canada, working at the University of Minnesota, and sessional lecturer in botany at McGill University, has been appointed junior plant physiologist in the Division of Plant Pathology and Botany at University Farm, St. Paul.

AT the Texas Agricultural Experiment Station C. H. McDowell, joint superintendent for the station and the Soil Conservation Service of the Blackland Substation of the U. S. Department of Agriculture, became on September 1 vice-director and agronomist of the station. He took the place of Dr. Paul C. Mangelsdorf, who resigned recently to become professor of economic botany and assistant director of the Botanical Museum of Harvard University. H. O. Hill, project supervisor of the Soil Conservation Service at the Blackland Substation, has been appointed joint superintendent.

IN the issue of SCIENCE for November 22, Dr. James Franck was referred to as professor of physics at the Johns Hopkins University. Dr. Franck came from the University of Göttingen to the Johns Hopkins University in 1934, but accepted a professorship of physical chemistry at the University of Chicago in 1938.

DR. ROBERT CUSHMAN MURPHY, of the American Museum of Natural History, has been elected president of the Long Island Biological Association. He succeeds Arthur W. Page, who for twelve years has presided over the affairs of the Biological Laboratory at Cold Spring Harbor, Long Island.

DR. EDWARD BARTOW, emeritus professor of chemistry at the State University of Iowa, has joined the research laboratories of the Johns-Manville Corp., Manville, N. J. Dr. Bartow will act as research consultant in connection with chemical problems involved in all phases of the research activities of the company.

COLONEL SIR EDWARD THORNTON, secretary for public health and chief health officer of the Union of South Africa, has been appointed director-general of the Medical Defense Services of the Union of South Africa.

DR. JAMES A. TOBEY, of New York, has been appointed chairman of the committee on food and nutrition in national defense of the Institute of Food Technologists. Dr. Tobey is director of the department of nutrition of the American Institute of Baking and is also lieutenant-colonel in the Sanitary Corps Reserve of the Medical Department of the Army. The Institute of Food Technologists was organized as a professional society in 1939, and now has more than 900 members throughout the United States.

GRANTS-IN-AID for research have been received recently by the following members of the College of Medicine of the State University of Iowa: Dr. Harry M. Hines, of the department of physiology, $5,000, from the National Foundation for Infantile Paralysis for study of regeneration of nerve and muscle; Dr. W. D. Paul, of the department of internal medicine, $3,500, from the Emerson Drug Company for the study of the action of bromides, and Dr. P. C. Jeans, of the department of pediatrics, $3,000, from the Mead-Johnson Company for a continuation of studies on infant nutrition.

A GRANT of $7,800 a year for three years from the Commonwealth Fund of New York is to be used for the study of kidney disease by Dr. Joseph M. Hayman, Jr., professor of clinical medicine and therapeutics at the School of Medicine and the Frances Payne Bolton School of Nursing of Western Reserve University. A similar grant was made by this fund for the same purpose in December, 1937.

THE Committee on Scientific Research of the American Medical Association has made a grant to Dr. David Polowe, who was recently appointed research fellow at Harlem Hospital, New York City, in support of his work on amylase activity in the blood.

DR. P. H. ROLFS, emeritus life member of the American Association for the Advancement of Science, who for nearly twenty years has lived in Brazil, is returning to the United States and will reside at Gainesville, Fla. The Agricultural College was founded by the State of Minas Geraes under Dr. Rolfs's direction.

DR. VICTOR K. LAMER, professor of chemistry at Columbia University, gave on November 15 at Yale University a lecture on "Kinetics and Equilibria of Exchange Processes in Deuterium Oxide," the third of the series of lectures on "The Applications of Stable and Radioactive Isotopes" sponsored by the department of physiological chemistry of the university.

HAROLD J. COOLIDGE, JR., of the Museum of Comparative Zoology of Harvard University, spoke on December 1 before the Men's Faculty Club of Columbia University. His lecture was entitled "To Asia for Apes," and was illustrated with motion pictures and sound recordings made in the jungles of Siam, Borneo and Sumatra.

DR. I. I. RABI, professor of physics at Columbia University, lectured on December 4 at a joint meeting of the Franklin Institute, the Physics Club and the Physics Colloquium of Philadelphia. His lecture was entitled "Radio Frequency Spectra of Atoms."

THE Pittsburgh Section of the American Chemical Society is sponsoring a popular public lecture on "Glass: To-day and To-morrow" by Dr. Alexander Silverman, head of the department of chemistry of the University of Pittsburgh, on the evening of December 11, in Carnegie Music Hall. The lecture will be illustrated with exhibits from the Glass Center in the New York World's Fair and from the Glass House in the Town of To-morrow.

DR. ELMER O. KRAEMER, biochemist in the research laboratories of the Franklin Institute, Philadelphia, delivered two lectures on December 3 under the auspices of the Foster Lecture Foundation of the University of Buffalo. The lectures were open to the public as well as to students. In the afternoon he spoke on "The Application of Centrifugal Methods in Colloid Research" and in the evening on "The Size and Shape of Large Molecules." Dr. Groves H. Cartledge, head of the department of chemistry and chairman of the Foster Lecture Committee, presided. The Foster Fund is endowed with the sum of $25,000 by Mrs. Orin D. Foster in memory of her husband.

THE first lectures of the De Lamar Institute for 1940–1941 of the School of Hygiene and Public Health of the Johns Hopkins University were given on November 19 by Dr. Virgil Sydenstricker, of Emory University, Georgia, on "Dietary Problems of the Southern United States"; on November 26 by Dr. Otto A. Bessey, of the Harvard Medical School, on "Morphological Defects in Dietary Deficiency States," and on December 3 by Dr. George R. Cowgill, of the Yale School of Medicine, on "Nutritional Deficiencies in Tropical America." On February 18 Dr. Edward H. Hatton, of the Northwestern University Dental School, will speak on "The Etiology of Dental Caries," on March 4 Dr. Max Theiler, of the Rockefeller Foundation, on "Studies on Poliomyelitis," and on March 18 Dr. Charles N. Leach, of the National Health Division at Montgomery, Ala., on "Recent Studies in the Epidemiology of Rabies."

THE Massachusetts Institute of Technology Chapter of the Society of the Sigma Xi has arranged for this year three lectures on "Man's Relation to his Environment." The subjects and the lecturers are: November 12, "Man's Relation to the Cosmos," by Dr. Cecilia Payne-Gaposchkin, Phillips astronomer at the

Harvard Observatory; January 14, "Man's Relation to the Earth," by Dr. Robert R. Shrock, assistant professor of geology at the Massachusetts Institute of Technology, and May 23, "Man's Relation to Other Men," by Dr. Kirtley F. Mather, professor of geology at Harvard University.

THE fifth annual symposium of the Division of Physical and Inorganic Chemistry of the American Chemical Society will be held in Havemeyer Hall, Columbia University, on December 30 and 31 and January 1. The general subject will be "The Structure of Molecules and Aggregates of Molecules."

THE Southern Section of the American Society for Horticultural Science will participate in the meetings of the Association of Southern Agricultural Workers to be held in Atlanta, Ga., from February 5 to 7. The program of the Southern Section will extend for a period of three days. On February 5 a conference will be held on the national sweet potato research program. On February 6 two symposia will be given, one entitled "Research with Tomatoes Grown in the South" and one other entitled "Research with Peaches." On February 7 a joint session will be held with the Soil Fertility Section of the American Society of Agronomy. Information may be obtained from Dr. J. B. Edmond, Clemson Agricultural College, South Carolina.

THE program of scientific and technical departments at the Rochester Athenaeum and Mechanics Institute in Rochester, N. Y., will be expanded and strengthened as the result of an endowment campaign of approximately $750,000. George H. Clark, Rochester industrialist, who offered to contribute two thirds of a dollar for every dollar pledged by the public before December 31, 1940, has given approximately $300,000. He offered to give $400,000 if $600,000 were raised from other sources. Three-year, post-high school courses are given at the institute in the industrial chemistry, electrical, mechanical, photographic technology, construction, food administration, home economics, applied art, retailing and publishing and printing fields.

DISCUSSION

DENTAL RESEARCH AT THE NATIONAL BUREAU OF STANDARDS

THE vital significance of the physical and chemical properties of dental restorative materials has, during the last twenty-one years, been amply demonstrated by a program of research at the National Bureau of Standards. The research was initiated by Souder and Peters in 1919, at the request of the War Department. The former, as chief of the bureau's dental reesarch laboratory, continues to supervise the research.

These men were able to show, through laboratory tests, defects in dental amalgam alloys, such as shrinkage and flow, in a large number of popular brands, which made it practically impossible for the dentists to place a filling which would give satisfactory service when these brands were used. As the research was extended to dental cements, gold alloys, denture resins and similar items, again many inferior trade brands were found indiscriminately assembled with and equally advertised with the superior brands.

The Weinstein Research Laboratories of New York City cooperated from 1922 to 1928 in the program of basic research. In 1928 the American Dental Association joined forces with the bureau. This was a most fortunate affiliation, as it permitted the extension of the research to include ample clinical tests by the association's members when and where desirable.

The first performance specification for a restorative dental material (dental amalgam alloy) was written by the National Bureau of Standards in 1925. With the assistance of the American Dental Association the number has been extended until there are now 12 such specifications. Each specification reflects the following influences:

1. Engineering principles involved in, and demands of typical dental restorations and appliances.
2. The suggestions and advice of representative members of the dental profession.
3. Information supplied by the manufacturers of dental materials.
4. A survey of the chemical and physical properties having a dental significance is conducted on each material.

The following items have been surveyed under the four-point program and are available to the dental profession, upon request, in specification quality: Amalgam, inlay casting investments, impression compound, inlay casting wax, inlay casting gold alloys, mercury, wrought gold wire alloys, zinc phosphate cements, silicate cements, denture rubber, hydrocolloidal impression materials and acrylic denture resin. These specifications are revised from time to time as new and improved materials are developed, thus enabling the dentist who demands specification quality always to be supplied with the highest quality materials available.

THE CERTIFICATION PLAN

The following plan was adopted to protect more completely the dentist in the purchase and use of materials and to guarantee the practical effectiveness of the specifications.

1. Following the adoption of a specification by the

American Dental Association its Research Commission invites the manufacturer to forward a formal certificate guaranteeing compliance of his product with the specification.

2. The manufacturer must also demonstrate to the Research Commission that he has adequate testing facilities and personnel and that he makes routine tests of his guaranteed products or makes use of a laboratory that does have such facilities for such tests.

3. The Research Commission procures in the open market a representative retail sample of the material which the manufacturer has guaranteed.

4. The sample is tested at the National Bureau of Standards to see whether or not it meets the association's specification.

5. If the material is found to comply with the requirements (items 1 and 2 having been met) the trade brand name is then placed upon a List of Certified Dental Materials.

This list is published from time to time in the *Journal* of the American Dental Association. Forty-five thousand dentists in the United States regularly receive these lists and are able to assure their patients as to the quality of materials they are using. Progressive manufacturers of these dental materials have gladly cooperated with both the Bureau and the Association in making the plan effective.

Since the work was started, approximately 100 reports have been printed. These reports have unquestionably had a salutary effect upon the production and use of dental materials. As a specific example one needs only to cite the effect of the technical reports and the specification for zinc phosphate cements. These publications caused, within one year after their appearance, the modification of practically every cement of this type which was manufactured in the United States. Manufacturers took the necessary steps to make their cements more uniform, less soluble, stronger, finer grained and more nearly free of arsenic.

Thus it can be seen that the foregoing cooperative research and supervised certification policy have been very effective in promoting the use of highest quality materials and in stimulating the testing of and research on dental materials both in dental schools and in manufacturing establishments. The program has been found mutually useful to the manufacturer, to the dental profession and to the public. It is believed that similar programs would work equally well in other fields, as they furnish a direct approach between the responsible manufacturer and his customers and a maximum of protection to the public.

GEO. C. PAFFENBARGER,
Senior Research Associate of the American Dental Association at the National Bureau of Standards

CONTROL OF PRICKLY PEAR IN AUSTRALIA

IN a recent publication[1] issued by the Imperial Bureau of Pastures and Forage Crops at Aberystwyth, Great Britain, among other matters there is an account of successful control of prickly pear in Australia through the introduction of insect enemies.

Various species of prickly pears (genus Opuntia of the Cactus Family) have been wide-spread weeds in Australia, where they were introduced from North and South America—*O. inermis* prior to 1839 and *O. stricta* about 1860. First planted for hedges and as a possible source of fodder these plants spread, until by 1925 over 60,000,000 acres were affected. About half of this area was occupied by a dense growth to a height of two to five feet, covering the ground to the exclusion of grass and herbage; the remaining 30,000,000 acres of infested land had great patches of prickly pear alternating with native vegetation.

The cost of eradication by chemicals or by mechanical means, digging or plowing, stacking and burning would have been about $50.00 per acre, while unaffected land adjacent was valued at only $2.00 to $5.00 per acre. Hence, year by year more land was abandoned, and holdings and homesteads deserted.

In 1920 the governments of the Commonwealth and of New South Wales and Queensland established the Prickly Pear Board to combat the infestation. Agents were sent to North and South America to study the diseases of prickly pears, but it was soon found that bacterial and fungous diseases offered little promise. Attention was then directed to insects attacking plants of the Cactus Family, and stations for study were established in many parts of the American continents; these stations were maintained either continuously or intermittently from 1920 to 1937. Insects which were discovered to feed upon prickly pears were fully studied, and when found not to attack plants of economic value were collected and shipped to Australia. There, in quarantine, they were tested again. About 150 species of insects restricted to cactus host plants were discovered, but only 15 were sufficiently promising to warrant their employment. They included the moth borer *Cactoblastis cactorum* from Argentine and Uruguay and other moth borers, besides species of cochineal insects, beetles, red-spider and two Coreid bugs. Following much experimentation there came the large-scale rearing of successfully acclimatized insects, their establishment in the field and later their mass distribution.

During the last ten years *Cactoblastis cactorum* has proved the chief agent for destruction of prickly pear; other insects introduced earlier were of some value,

[1] Herbage Publication Series, Bulletin 27, "The Control of Weeds."

but they have all diminished in numbers or have even completely disappeared. Cactoblastis is distributed in the egg stage. The eggs are laid in chains, or "egg-sticks"; these can be handled and transported without injury, having first been glued to strips of paper or placed in wax-paper quills. Field workers, traveling roads and trails through prickly-pear land, pin the paper strips or quills to cactus plants. When the insects are once established in any locality no further distribution is necessary except to isolated and non-contiguous areas.

Cactoblastis larvae devour the interior of the cactus branches, readily boring from one joint to another and even penetrating the roots; furthermore, their activities are accompanied by rotting due to bacteria and fungi. When only the above-ground parts of the cactus plant are destroyed by an onslaught of Cactoblastis a regrowth takes place from the roots, but this new growth is very succulent and is soon destroyed by a succeeding attack of the moth borer.

At the present time (1940) prickly pear infestation has been reduced from 75 to 95 per cent. of that in 1925. In the greater part of formerly infested areas the pest is under complete control; the scattered remaining plants are not a menace—indeed, they are of value for breeding of Cactoblastis. Areas of former dense prickly pear are now being used for crops, for dairying and for grazing. The great bulk of former prickly pear territory is now reclaimed; it will never revert to its previous useless state.

FRANCIS RAMALEY

UNIVERSITY OF COLORADO

THE DENS AND BEHAVIOR OF THE DESERT TORTOISE

STUDIES of the desert tortoise, *Gopherus agassizii*, have shown a definite behavior pattern in which the individuals tend to congregate together in winter dens during cold weather, spread out over nearby areas during moderate weather, and descend into short individual burrows when it is too hot. The studies have been carried out on the Beaver Dam Slope in extreme southwestern Utah since 1936. The area selected was particularly favorable for the winter den concentrations, hence it is not certain at present whether this pattern is general over all its range.

More than 200 tortoises have been marked for individual identification by burning the letter U into different plates or combinations of plates on different individuals so that each one so marked could be definitely identified. During 33 visits to the area, tortoises have been recaptured from time to time, the number of recaptures of individuals ranging from 0 to 11 times. The total captures of tortoises reaches nearly 500 up to date.

The 68 winter dens we have studied are found mostly in compact gravel banks, and usually extend from 5 to 30 feet horizontally into the bank. In cross-section, they are somewhat oval; in length they may be straight, bent, forked or have enlarged chambers. The size does not generally permit entrance by man, but several have been excavated to permit investigation.

The dens are regularly occupied from November to February inclusive, although there undoubtedly is a slight amount of movement from den to den during these months. March and October appear to be the months of transition. During March, fewer and fewer, and during October, more and more are found in the dens. From April to September inclusive, the dens are deserted except for occasional stragglers.

During this period, the tortoises are scattered over the surrounding terrain, usually as solitary individuals, occasionally as copulating pairs. As long as the temperature is comfortable, they do not appear to bother about shelter. As the days get warmer, they tend to move into the shade of a bush, but when the days get hot and the ground vegetation parched, they resort to the summer holes.

These summer holes dip sharply downward 3 or 4 feet and are usually deep enough to protect the tortoises from the torrid heat of midday. They usually emerge at night when the temperatures are more propitious.

The territory covered by individual tortoises, indicated at least in part by plotting the points of capture on a map, is not large. Some individuals with at least 10 capture records do not cover an area of more than ten acres. Others wander farther afield, but the largest territory indicated up to date is only about 40 acres. These records, while not necessarily conclusive, at least indicate that the tortoises are closely restricted to a small territory.

A more detailed report of these studies will be published elsewhere at a later time.

A. M. WOODBURY

UNIVERSITY OF UTAH

ROSS HARDY

DIXIE JUNIOR COLLEGE

ELECTRIC FENCES THAT REPEL DEER

PROTECTION of growing crops against deer by the use of electric fences has become an acute necessity in many parts of Texas. In agricultural areas which also contain suitable range for deer, the perennial question of balancing these conflicting interests has engaged alike the attention of landowner and sportsman, and with some success. For the past two years experimentation with several kinds of fences in central Texas has resulted in the selection of the most successful type. Improper installation and therefore failure of such fences to do any good has resulted in hasty

and harmful conclusions. It was learned that a single electrified wire, without any supporting fence near, was adequate to stop cattle and horses, but not deer. The deer-repellent fence, which has proved successful at two places in Kerr County where deer are abundant, was installed by State Game Warden Bill Garrett as follows: On the outside of a ten-acre farm, five feet from the regular fence, a single No. 9 telephone wire was strung on insulators 20 inches above the ground and charged with a six-volt dry cell battery.

The electrical device consists of an encased six-volt dry battery with transformer and interrupter. The battery is good for about four months; the other parts last indefinitely. (If the electric wire is to extend more than two miles it is advisable to have an electrician calculate the wattage and size of coil needed for the distance contemplated.) Other sources of power may be used, but the dry battery is preferred as being absolutely safe. The outfit can be bought at prices ranging from $12.00 to $20.00. The only maintenance cost would be the cutting of weeds or branches along the fence to prevent leakage.

The idea of placing the electric fence five feet from the regular fence might appear to be fantastic, but there is a reason. When a deer approaches a fence to jump over and finds two fences set five feet apart, he does not like the idea of so long a flat-footed jump. He pauses to pick the line of least resistance. Whether he decides to hop over the single wire or crawl under, he is apt first to make an inspection with his nose or otherwise rub against it and get a violent shock. Cattle thus shocked have avoided the fence long after the discontinuance of an electric current. All live stock, including hogs, respected the fence, and deer, which are very fond of tomatoes and potato vines, were not tempted to eat of the forbidden fruit during a three months' test.

J. G. BURR

GAME, FISH AND OYSTER COMMISSION,
AUSTIN, TEXAS

J. PETER LESLEY AND JOSEPH LESLEY

BIBLIOGRAPHERS as well as geologists should use extreme care when working with papers by either of the Lesley brothers, for the second state geologist of Pennsylvania, who was baptized Peter Lesley, at varying times throughout his life signed his name Peter Lesley, Peter Lesley, Jr., J. P. Lesley and J. Peter Lesley, the "J" standing for junior, while his brother Joseph, also a geologist, sometimes signed his name Joseph Lesley, Jr. The six variations listed above may be considered correct on the basis of actual usage by the individuals, but additional incorrect combinations have also appeared in print. Joseph P. Lesley and Joseph P. Lesley, Jr., each of which has been applied to both brothers, and Joseph Peter Lesley, John Peter Lesley and John P. Lesley which have been used for Peter Lesley, are all incorrect. Not only have wrong names been used in the past but bibliographic references have become badly mixed. Papers written by Peter Lesley have been accredited to Joseph and articles by Joseph attributed to Peter.

A more detailed paper on this problem appeared in the *Proceedings of the Pennsylvania Academy of Sciences,* 1940.

LAWRENCE WHITCOMB

LEHIGH UNIVERSITY

QUOTATIONS

THE BRITISH SCIENTIFIC ADVISORY COMMITTEE

BY means of the Scientific Advisory Committee, the appointment of which is announced this morning, the scientific workers of the country are given a more defined place in the national effort. The distinguished men, acknowledged leaders in their own branches of science, who form the new committee will bring more than their individual, or even their combined, abilities to the services of the nation. They will establish a center and rallying point and be a means of releasing and employing scientific resource and skill. They will also be a channel of communication through which the spontaneous suggestions of scientific workers may be examined and tried.

The advisory powers of the committee will be employed at the instance of the Lord President of the Council, who will indicate particular problems for investigation, or of Government Departments which may ask for assistance in selecting suitable men to undertake particular lines of research. In exercising this function the members of the committee have a knowledge of varied and wide fields of science, and of the men engaged in scientific work, which will give access to resources that, in a mechanical and scientific war, must be utilized to the fullest extent. Here, it seems, the committee is to be at the disposal of the Government.

Even more significant is the conferment on the committee of the duty of seeing that no new scientific or technical developments go neglected. The committee will therefore be a sort of examining board for original ideas, which, passing its scrutiny, will go forward hallmarked for practical experiment or certain use. A clearing house for inventive ideas is not a new provision; but the advisory committee is more than that by reason of its constitution and its powers. It has the responsibility of sifting original ideas and inven-

tions and the highest competence for the task, but it has no need to wait for ideas to reach it from outside. The committee itself is a kind of scientific power house from which great things may be expected.—*The London Times.*

THE FUTURE OF POLISH SCIENCE

SINCE the restoration of Poland after the War of 1914–18 concentrated efforts have been made to develop and coordinate the scientific work of the country. During a difficult period of reconstruction, great progress was achieved and, in addition to the six universities, a number of other centers were available for learning and research. Before the outbreak of the present war, there were approximately 850 professors, 520 assistant professors and 1,600 research assistants and readers; the number of students being about 48,000. With the overrunning of Poland by Germany and the U.S.S.R., systematic and thorough methods have been employed to destroy its scientific life. This is being achieved in German-occupied Poland by the imprisonment of university staffs and scholars, the commandeering of specimens and equipment for use in the German Reich, the destruction of publications and libraries, and the closing of all centers of learning and higher education. Similar conditions exist in Soviet-occupied territory. Professors and research students have no means of continuing their work and the future of Polish science has been further jeopardized by the closing of secondary schools, thus destroying the source of future students. Fortunately, however, some forty-six Polish scientific workers have been able to reach England. They comprise among their subjects, anatomy, zoology, bacteriology, chemistry, physics and branches of engineering and mechanics; the majority can speak at least three languages. It is the Polish Government's earnest endeavor to conserve, through these men, the future of science in Poland. A few will be able to obtain British Council scholarships and will be placed by the council in British research institutions. The remainder will be given partial assistance from the very modest funds possessed for this purpose by the Polish Government.

The difficulties confronting the research workers who have no personal contacts in Great Britain are very great, not least among them the understandable antipathy and mistrust of foreigners which now exists in the country. The importance of securing the future of science and learning in Poland, however, will be fully realized, and by assisting to bring about the admission of Polish workers to research institutions in the British Commonwealth of Nations, British men of science can thus help to ensure a nucleus of Polish intellectuals. Also it must not be forgotten that Poland is an ally of Great Britain, who has at no time and in no way failed her, and that a common bond of hardship has drawn the two countries together in friendship.—*Nature.*

SCIENTIFIC BOOKS

RECENT PUBLICATIONS OF THE BRITISH MUSEUM (NATURAL HISTORY)

THE war has been going on for more than a year, but the British Museum continues to publish valuable works on various aspects of natural history. These publications, at least in the main, represent work done prior to the beginning of the war, but it is the policy to continue scientific work as circumstances permit, work which will have a permanent value when the war is only a matter of history. In the same spirit, the British journal *Nature* frequently reviews German scientific books, accepting them according to their merits, regardless of the conflict between the countries. The books and papers listed below are those which I have just received from the office of SCIENCE.

Karl Fiedler. Monograph of the South American Weevils of the Genus Conotrachelus. February, 1940. 365 pp., many illustrations. Dr. Fiedler, Sanitätsrat in Thuringia, had been studying the South American weevils for a number of years, and a few years ago was invited to revise and describe the material of this large genus which had accumulated in the British Museum. He found in the collection no less than 216 new species, and included in his study about 200 new species obtained from other sources. The complete list, including those previously described, includes about six hundred species. Many of these are important pests of cultivated plants, but for the majority the habits and life history are unknown. The large and well-drawn figures greatly facilitate determination. This excellent book, by a citizen of an enemy country, is published in German. It is remarked in the preface that it would be a heavy expense to translate it into English, and mistakes might be made in the process.

W. H. Evans. A Catalogue of the African Hesperiidae, indicating the classification and nomenclature adopted in the British Museum, 1937. 212 pp., 29 plates. Brigadier Evans, well known for his studies of the Oriental skipper butterflies, undertook to revise those of the African fauna, represented in the Museum by nearly 25,000 specimens, belonging to 70 genera, 421 species and 157 subspecies. The descriptions are very brief, but there are good colored figures of the new species, and of others which had

not previously been figured. There are also small diagrammatic figures of the genitalia of all the species. Thus it would seem that it should be possible to recognize the species, and with this aid, a worker in Africa would find ample opportunity to work out the life histories, most of which are unknown. It is a peculiarity of this author (certainly not a policy of the Museum) that when describing new forms, he hardly ever cites the collectors. This is much to be regretted, and I think it would be justifiable to publish an article supplying the missing information. The Museum has depended so much for its rich collections on collectors who have worked, often under very trying conditions, to supply desirable materials that it seems inexcusable to ignore them when publishing their discoveries. There is an excellent bibliography, and when the species have been previously figured, references to the figures are given.

W. D. Lang, Stanley Smith and Henry Dighton Thomas. Index of Palaeozoic Coral Genera. April, 1940, pp. 231. This is, in the main, a carefully compiled and fully annotated index of the genera of Paleozoic corals, but it is of general interest because of the long and very interesting introduction by Dr. Lang, which deals with such matters as the Old and New Paleontology, Polyphyletic Genera, Taxonomy, Nomenclature, etc. When I was a boy, I resided for a time at Margate, on the coast of Kent; the coast which from its white chalk cliffs was long ago named Albion. There lived in the town a Dr. Arthur Rowe, a physician, who took for his hobby the detailed study of the fossils in the chalk. He discovered that this apparently uniform deposit in reality represented a series of epochs, which could be distinguished by their fossils. Rarely has a hobby-horse been ridden to such good purpose. Now, after a long interval, Lang writes under the heading "The New Palaeontology," "Although a new movement can seldom be attributed to one individual, I suppose that no single author, in Britain at least, did so much to introduce the new paleontology as did the late Arthur Rowe in following up the pioneer work of Charles Barrois. His classic work on the sea-urchins of the chalk, published in 1899, at once gave an opening (so it seemed to his generation) to the floods of pent thought which had been accumulating in the minds of many paleontologists, but lacked a means of expression." (The further, highly illuminative, discussion of this topic is too long to quote.) At the end of his introduction, Lang dramatizes the subject as follows: "With due regard to the considerations detailed above, and after more than twenty years of research upon the Paleozoic corals, we enter with some diffidence upon a formidable task. But, after all, the play's the thing; the stage is set, the curtain is rung up. The genera with their attendant genotypes will enter, make their bow, and retiring to collect each its appropriate species, will reappear with them to unfold the evolutionary plot as formation succeeds formation until, in the Permian act, the curtain falls upon an unfinished drama. A coral fauna is there left in the midst of its evolution. Its future is an enigma, and we have no present knowledge as to whether complete extinction overtook it, or whether it underwent a rapid and radical reorganization, to reappear in Triassic times as a fauna of typical Hexacorals."

Thomas Maxwell Harris. British Purbeck Charophyta. 1939, pp. 83 and 17 excellent photographic plates. The subject is treated with beautiful exactness and detail, but it is not found that the Purbeck fossils throw any real light on the evolution of the group. In that remote period were plants with "the vegetative organization of *Chara,* the most elaborate of the modern forms."

Lucien and Jean Morellet. Tertiary Siphoneous Algae in the W. K. Parker Collection. 1939. 55 pp. and six photographic plates. A careful revision, with much interesting detail.

Max H. Hey. Second Appendix to the Catalogue of Meteorites. 1940. 136 pp. Since the publication of the first appendix in 1927, specimens representative of 91 falls new to the collection has been incorporated. The new catalogue lists the meteorites alphabetically under their names (each fall receiving a special name), with annotations. There is a list of meteorite craters, with full references to literature.

Catalogue of the Books, Manuscripts, Maps and Drawings in the British Museum (Natural History), Vol. viii, supplement P–2. Feb., 1940. 515 pp. A great catalogue, invaluable to librarians, curators of museums and others.

Carolus Linnaeus. Systema Naturae. Tenth edition, Vol. 1 (the animal kingdom). 1939. As the tenth edition of the Systema Naturae, the foundation of our binomial nomenclature for animals, had become extremely rare, the museum reprinted it in facsimile, and it can be obtained for the modest sum of ten shillings and sixpence. It should have a great sale in America.

Ruwenzori Expedition. Vol. iii, Nos. 6 to 10. February, 1940. Deals with representatives of five families of beetles found on the expedition to Mt. Ruwenzori in Africa.

The John Murray Expedition. 1933–34. Scientific Reports. These reports, dealing with the work of the expedition in the Indian Ocean, are full of interesting details which invite comment, but we can only enumerate the titles here:

Published October, 1939. Mortensen on the Echinoidea. Chopra (Zoological Survey of India) on the

Stomatopoda. Stanley Gardiner on the Madreporaria and on the Ecology of Solitary Corals. Foxon on Stomatopod Larvae. H. L. Clark (Harvard University) on Ophiuroidea.

Published November, 1939. E. F. Thompson on Chemical and Physical Investigations. Stubbings on Stratification of Biological Remains in Marine Deposits (attempt to determine the warm and cold periods of the past by the foraminifera). Norman on the Fishes. (With a synopsis of the oceanic genera of Brotulidae.)

Published February, 1940. S. J. Hickson on the Gorgonacea, with notes on two species of Pennatulacea.

Published March, 1940. Stubbings on the Cirripedia. Wiseman and Bennett on the Distribution of Organic Carbon and Nitrogen in Sediments from the Arabian Sea. Seymour Sewell on the Copepods, Harpacticoida (a large report, with much interesting discussion).

T. D. A. COCKERELL

AQUATIC PLANTS

A Manual of Aquatic Plants. By NORMAN C. FASSETT. vi + 382 pp. New York: McGraw-Hill Book Company, Inc. 1940. $4.00.

THE aim of this book is to aid in the identification of aquatic plants, whether in sterile or in flowering condition. The forms included are those obvious to the unaided eye and which under normal conditions germinate and grow with at least the base of the plant in water. This interpretation eliminates most of the algae but permits the liberal inclusion of terrestrial forms normally found in moist habitats, thereby greatly increasing the usefulness of the book for general purposes. The region covered includes Minnesota, Iowa and Missouri, then broadens eastward to the Gulf of St. Lawrence and Virginia. A few helpful references are included with each group, and there is a bibliography on the uses of aquatic plants by wildlife.

The volume consists mainly of keys and figures. The former, which include most of the descriptive material, cover more than one hundred pages, while the latter fill considerably over two hundred pages. This liberality of illustration is especially helpful. The figures are original drawings supplemented by a limited number of habitat photographs. In general, the figures are excellent, both in outline and in sampling of detail; a feature of value is the inclusion of the major venation of leaves illustrated. The plate including *Vallisneria* might well be modified, since one drawing involves figures of unequal scale. On the preceding page, in connection with the illustrations of *Anacharis,* terms relating to the elongated portions of the pistillate and staminate flowers appear reversed. A brief appendix dealing with the uses of water plants by animals is both a useful summary and a model of compactness. The portion devoted to fish perhaps merits extension, but this would have involved greater emphasis on algae.

This book is a welcome addition to the literature of aquatic biology. Because of its organization it may be used by the layman, since the author adheres to the plan of aiding the practical worker, but it will be welcomed as well by the experienced botanist. Convenience of the user is greatly facilitated by having keys and figures closely associated. Brevity of treatment is achieved by leaving much to the manuals to which necessary references are made. But the volume is not a crutch to help to bigger books, for its treatment usually affords a satisfying definiteness without supporting references.

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REPORTS

THE COTTON ROOT-ROT TOUR AND CONFERENCE OF 1940

WORKERS on the cotton root-rot disease, caused by *Phymatotrichum omnivorum,* assembled for a tour and series of conferences, extending from Greenville to College Station, Texas, August 6–9, 1940. Call for this meeting was issued by Dr. A. A. Dunlap, chairman of the root-rot committee of the Cotton Disease Council. Periodic meetings of this kind, at which research workers on the problem have met to exchange ideas, viewpoints and results, have played a part in the rapid advance of knowledge about this very serious disease. The geographic limitation of the work to Southwest United States has made it possible for a majority of those engaged in studies on the problem to attend some if not all of the conferences. Group discussion of the results and of points to be attacked has doubtless avoided some needless duplication of work, aided in encouraging a wider range of attack on the problem, and has obviously facilitated rapid confirmation of new findings.

The root-rot conferences were at first winter meetings with more or less formal reports of progress. The series began with a meeting at College Station on December 13–15, 1927. Accounts of the meetings and abstracts of papers presented at the second to fifth conferences (1929–32, respectively at College Station, Temple, College Station, and Austin) were published in *Phytopathology.* The sixth conference, held at

College Station on December 4, 1934, was informal and abstracts of results were not published. After an interval of three years, the seventh conference, September 21–24, 1937, took the form of a tour of field experiments from Greenville to College Station, with informal meetings along the line of travel. The 1940 conference, making the eighth of the series, took place again after an interval of three years and was also a tour of field stations and plot experiments with sessions at points along the route for discussion of field and laboratory results.

The tour began with inspection of work at the U. S. Cotton Field Station at Greenville, during the morning of August 6. The party then proceeded to Temple, via Rosebud, where soil fertility plot experiments were seen. The morning of August 7 was devoted to a rapid examination of extensive root-rot work at Substation No. 5 of the Texas Agricultural Experiment Station, near Temple. Field plots of the Clayton Foundation of the University of Texas were seen that afternoon in the vicinity of Austin, and laboratories at the university were visited during the evening. On August 8, soil fertility plots were visited at Kimbro and Elgin; and plot experiments at Brenham were viewed en route to College Station. The program concluded with an informal session at College Station on August 9, during which experimental work not visited on the tour was briefly summarized and discussed.

As usual, attendance at this meeting included most of the workers engaged in study of cotton root-rot, along with the heads of the organizations concerned. Omitting visitors, the 41 attending may be classified as: plant pathologists 9, agronomists 7, plant physiologists 4, soil bacteriologists 4, agricultural aides 4, chemists 3, geneticists 3, substation superintendents 3, soil technologists 2, entomologists 1 and botanists 1. Research groups represented were the University of Arizona Agricultural Experiment Station; the U. S. Department of Agriculture Cotton Field Stations at Sacaton, Arizona, and at Greenville, Texas; the U. S. D. A. Divisions of Cotton and Other Fiber Crops and Diseases, Soil Microbiology, and Cereal Crops and Diseases; the U. S. D. A. Soil Fertility Laboratory at Austin; the Clayton Foundation of the University of Texas; the A. and M. College of Texas; and the Texas Agricultural Experiment Station at College Station and Substations No. 5 at Temple and No. 15 at Weslaco.

No prepared papers were presented at the sessions of this meeting and results of the work were given informally. Publication of abstracts of these results is therefore not contemplated.

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SPECIAL ARTICLES

A QUANTITATIVE, ABSOLUTE METHOD FOR THE ESTIMATION OF COMPLEMENT (ALEXIN)

THE quantitative absolute methods introduced by this laboratory[1] for the study of specific immune precipitation and agglutination have now been extended to the estimation of complement (alexin). If, as defined by Muir,[2] complement is "that labile substance of normal serum which is taken up by the combination of an antigen and its anti-substance (immune body)," then complement may be measured in milligrams of nitrogen per milliliter as outlined below.

Quantitative precipitin estimations were run with proportions of antigen and rabbit antisera such that not quite all of the antibody was precipitated. In this way disc-like precipitates were avoided, as these are difficult to disintegrate and wash thoroughly. All guinea-pig serum used was neutralized to phenol red in the hope of reducing the solubility of the specific precipitates. The rabbit sera (inactivated) contained sufficient antibody nitrogen for quantitative estimations at dilutions which were not anticomplementary. 1.0 ml portions of antiserum dilution were added, each in triplicate, to 5.0 ml of 0.9 per cent. saline, 5.0 ml of heat-inactivated guinea-pig serum and 5.0 ml samples of an unheated portion of the same guinea-pig serum pool. The tube contents were mixed and 1.0 ml of antigen dilution was added to each tube and mixed. Blank tubes were also set up with active and inactivated complement to which antigen or antiserum alone was added. After 1 hour at room temperature the tubes were centrifuged in the cold and the analyses were completed in the usual way,[3] except that in order to assure maximum accuracy all supernatants were recentrifuged as in the agglutination procedure[4] and all tubes were washed three times with chilled saline instead of twice, owing to the large amounts of guinea-pig serum used. Washings were tested and found free from complement. The hemolytic unit of complement activity was measured in the usual way with 0.2 ml of minimally sensitized sheep red-cell suspension (2 to 2.5

[1] Reviewed in *Chem. Revs.*, 24: 323, 1939; *Bact. Revs.*, 3: 49, 1939.

[2] R. Muir, "Studies on Immunity," Oxford University Press, London, 1909.

[3] M. Heidelberger and F. E. Kendall, *Jour. Exp. Med.*, 61: 559, 1935; 62: 697.

[4] M. Heidelberger and E. A. Kabat, *Jour. Exp. Med.*, 67: 545, 1938.

per cent. final concentration). Hemolytic units in the supernatants from the tubes which had contained active complement were estimated from the largest non-anticomplementary volume failing to show appreciable hemolysis, and were therefore actually much less than the number indicated, except in the second experiment, in which complete hemolysis was actually obtained at the level given. The results are summarized in Table 1.

TABLE 1

Precipitating system, rabbit serum	Hemolytic units of complement		Nitrogen precipitated			Difference between active and inactivated complement	N precipitated per 1,000 hemolytic units of complement
	Added	Left in supernatant	Antigen, serum, saline	Antigen, serum, heat-inactivated complement	Antigen, serum, complement		
			mg	*mg*	*mg*	*mg*	*mg*
Pn III*	1,250	<10	0.588	0.598	0.720	0.122	0.10
" " †	1,250	40	0.388	0.406	0.562	0.156	0.13
Ea-anti-Ea‡	1,000	<<75	0.478	0.484	0.604	0.120	0.12

* Antipneumococcus Type III serum, specific polysaccharide of Type III pneumococcus (S III).

† In this experiment and the one following the entire guinea-pig serum pool was filtered through Gradocol membranes of 700 mμ average pore diameter.

‡ Anti-egg albumin serum, crystalline egg albumin. In this experiment a Type I antipneumococcus horse specific precipitate, known not to fix complement (H. Zinsser and J. T. Parker, *Jour. Immunol.*, 8: 151, 1923; K. Goodner and F. L. Horsfall, Jr., *Jour. Exp. Med.*, 64: 201, 1936) was first formed in the active and inactivated complement used. Identical amounts of nitrogen (0.437, 0.437 mg per 5.0 ml) were precipitated (0.413 mg N from the saline-SI-anti-PnI blank), but the anticomplementary action of the horse serum used reduced the number of effective hemolytic units by one third. The value given in the table is that originally found.

It would appear, therefore, that roughly 1,000 hemolytic units, as measured above, correspond to about 0.12 mg of complement N, as defined above. If complement is actually a globulin, as now seems established,[5] this would correspond to about 0.75 mg of protein and indicate that 1 ml of guinea-pig serum ordinarily contained about 0.024 to 0.03 mg of complement N, or 0.15 to 0.20 mg of actual complement. Additional computations which follow directly from this analytical result and a discussion of some of the implications of these findings, which are being extended in several directions, will be given in a more detailed paper now in preparation.

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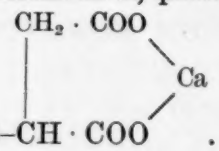
[5] T. W. B. Osborne, "Complement or Alexin," Oxford University Press, 1937; E. E. Ecker, L. Pillemer, C. B. Jones and S. Seifter, *Jour. Biol. Chem.*, 135: 347, 1940.

THE THERAPEUTIC EFFECTIVENESS OF A PRACTICALLY NONTOXIC NEW COMPOUND (CALCIUM AUROTHIOMALATE) IN EXPERIMENTAL, PROLIFERATIVE, CHRONIC ARTHRITIS OF MICE

EARLY in 1939, one of us (A. B. S.) reported that it was possible by intravenous injection of a newly discovered pleuropneumonia-like microorganism to produce an experimental, proliferative, chronic arthritis in mice which clinically and pathologically bears a close resemblance to human rheumatoid arthritis.[1] Although repeated attempts have failed to reveal the presence of such a microorganism in the human disease,[2,3,4] it was found that the experimental arthritis of mice responded to certain chemotherapeutic agents in a manner paralleling their alleged effectiveness or ineffectiveness in rheumatoid arthritis.[5] Thus, of many substances tested, the inorganic and organic gold compounds were the only ones capable of exerting a curative effect on the experimental arthritis in mice, despite the fact that they had no demonstrable action on the etiological agent *in vitro*. It was also found that the toxicity, as measured by the lethal effect on mice, and therapeutic effectiveness were a function of different properties of the gold compounds, and that depending upon their structure and mode of administration there was a wide range in the margin of safety as reflected in chemotherapeutic indexes which varied from 2 to over 30.[5] The present study obtained its orientation from the observation that while colloidal preparations of gold or of gold sulfide were therapeutically inert, a distinct, though delayed, curative effect followed the administration of large doses of an insoluble gold compound, calcium aurothioglycolate, of which mice tolerated an amount at least ten times as large as the minimal therapeutic dose.[5]

The purpose of this communication is to report that it has proved possible to prepare a compound with practically no toxicity and even greater therapeutic effectiveness simply by converting sodium aurothiomalate[6] into calcium aurothiomalate. The addition of an excess of $CaCl_2$ to a solution of sodium aurothiomalate leads to practically complete precipitation of a com-

[1] A. B. Sabin, SCIENCE, 89: 228, 1939.
[2] *Ibid.*, SCIENCE, 90: 18, 1939.
[3] A. B. Sabin and B. Johnson, *Proc. Soc. Exp. Biol. and Med.*, 44: 565, 1940.
[4] G. M. Findlay, R. D. Mackenzie and F. O. MacCallum, *Brit. Jour. Exp. Path.*, 21: 13, 1940.
[5] A. B. Sabin and J. Warren, *Jour. Bact.*, 40: 823, 1940 (in press); also unpublished observations.
[6] We are grateful to Merck and Company for supplying the sodium aurothiomalate (myochrysine) used in this investigation.

pound which, from the total yield and the proportion of gold and calcium in it, probably has the following formula:  . The theoretical yield of calcium aurothiomalate on the basis of complete precipitation is 0.9849 gm per gm of sodium aurothiomalate, and the actual yield was 0.9840 gm. The dry compound is a pale yellow powder which neither changes color nor loses weight after being heated in an oven at 100° C. for 24 hours. It is insoluble in water, alcohol and ether, but is completely soluble in tenth-normal HCl. Calcium aurothiomalate forms a uniform and relatively stable suspension in oil of sweet almonds and it was in the form of such a suspension that it was tested for toxicity and therapeutic effectiveness. While an aqueous solution of sodium aurothiomalate administered intramuscularly to 20 gm mice is lethal for 10 to 20 per cent. of animals in a dose of 6 mg, for 30 to 40 per cent. in doses of 7 to 10 mg, and for nearly 80 per cent. of animals in doses of 15 mg, it was found that all 54 mice inoculated with amounts varying from 10 to 250 mg of calcium aurothiomalate remained well over a period of 6 weeks or more without exhibiting any obvious signs of illness. The therapeutic effectiveness of calcium aurothiomalate was determined in 90 mice which were inoculated with amounts varying from 0.25 mg to 20 mg one week after the onset of arthritis. The total dose was administered intramuscularly in one injection. The arthritis disappeared completely in 90 per cent. of 70 mice which were treated with 1 mg or more of calcium aurothiomalate, but in less than 25 per cent. of those which received the 0.5 mg and 0.25 mg doses, and not at all in the 30 control mice which were untreated; 85 per cent. of 20 mice receiving the 1 mg dose made a complete recovery. Under similar conditions, *i.e.*, administering the total dose in one injection, the minimal therapeutic dose of sodium aurothiomalate is 2.0 to 2.5 mg. Calculation would show, therefore, that in mice "the margin of complete safety"[7] is at least 100 times greater for calcium aurothiomalate than for sodium aurothiomalate. A curative effect was also obtained when the total minimal effective amounts of calcium aurothiomalate were divided into ten equal doses and administered at 48-hour intervals. Calcium aurothiomalate was also found to be approximately ten times more effective therapeutically than calcium aurothioglycolate. Insoluble barium and strontium salts of aurothiomalate similar to that of calcium were also prepared, but no comparative study of their biological properties has been made as yet.

At the present time the toxicity of most available gold compounds is perhaps the greatest barrier to their more wide-spread use in the treatment of rheumatoid arthritis in man. There are also certain indications that some of the toxic manifestations in man may be due to sensitization or other factors which may not be measured by the lethal effect of a compound in mice. Only clinical trial, therefore, can indicate whether or not calcium aurothiomalate will be comparatively as safe and effective in human beings as it is in mice.

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PHOSPHATE ACCEPTORS IN "RESPIRATORY PHOSPHORYLATION" IN MUSCLE TISSUE

IN our studies on the phosphorylation, coupled with the aerobic oxidation of various substrates in cardiac muscle tissue and on the action of enzyme poisons on this process, we used creatine as the acceptor of phosphate.[1] Adenylic acid proved to be a less convenient acceptor, most likely for the reason that it is deaminized. At present we have undertaken a more systematic investigation of the acceptors of phosphate. As the oxidizable substrate we used succinate, the oxidation of which to the fumarate stage is coupled with phosphate esterification, as we demonstrated some time ago.[2, 3] For the experiments cardiac muscle, red muscle and extracts from rabbit's heart have been used; the phosphate acceptors tested were glucosemonophosphate, glucose, glucose + hexokinase (from yeast), glycogen and creatine. In all experiments hexosemonophosphate displayed the most active capacity of accepting phosphate, in accordance with its behavior in brain tissue.[4] No phosphorylation takes place under anaerobic conditions; and in the absence of succinate the esterification is markedly diminished, especially upon addition of sodium fluoride. The products of hexosemonophosphate phosphorylation were shown to be hexosediphosphate (time course of hydrolysis, liberation of inorganic phosphate by phenylhydrazine) and phosphotrioses (alkali-labile phosphoric esters).

Glucose is distinctly esterified, but only in the pres-

[7] The "margin of complete safety" $\left(\frac{\text{maximal dose tolerated by nearly 100 per cent. of mice}}{\text{minimal therapeutic dose}}\right)$ is used here because it describes a property which is different from that represented by the chemotherapeutic index, $\left(\frac{\text{minimal dose lethal for 50 per cent. of animals}}{\text{minimal therapeutic dose}}\right)$.

[1] V. A. Belitzer and E. T. Tzibakova, *Biochimia* (Moscow), 4: 516, 1939.

[2] *Ibid.*

[3] Phosphorylation attending the oxidation of succinic to fumaric acid in kidney extracts has also been observed a little later and independently by S. P. Colowick, M. S. Welch and C. F. Cori, *Jour. Biol. Chem.*, 133: 359, 1940.

[4] S. Ochoa, *Nature*, 145: 747, 1940.

ence of hexokinase does it become a powerful phosphate acceptor. Glycogen induces a decrease of phosphate that is slower and less dependent on the presence of oxygen than the esterification of hexosemonophosphate. Respiratory phosphorylation in this instance is evidently involved only in the transformation into hexosediphosphate of the glucose monophosphoric ester formed by phosphorolysis. The esterification of phosphate in the presence of different acceptors is shown in Table 1.

TABLE 1

200 MG. MINCED RED MUSCLE OF RABBIT. TOTAL VOLUME 1,7 μL. SUCCINATE 0,05 M, $MgCl_2$ 0,004 μ, PHOSPHATE BUFFER 0,015 M (pH 7,4), $NaHCO_3$ 0,008 M. 40 MIN. AT 20° IN O_2. ADDITIONS: GLYCOGEN 4 MG., OTHER ACCEPTORS—25 μ M PER SAMPLE. H_3PO_4 DISAPPEARED (MG. P)

Without added acceptors	Glucose	Glucose + hexokinase	Hexose-monophosphate	Creatine	Glycogen
0,02	0,04	0,33	0,45	0,13	0,19

In spite of the presence of preformed glycogen in the muscle tissue, esterification was negligible without added phosphatic acceptor: glycogen added artificially is phosphorylated much more readily than the glycogen of the tissue. Hexosemonophosphate, likewise a constant ingredient of muscle tissue, exhibits similar behavior; a rapid accumulation of hexosediphosphate and phosphotriose in aerobiosis takes place only at the expense of added hexosemonophosphate. It is difficult at present to interpret this differential behavior of endogenous and added acceptors.

In several experiments the competition between simultaneously added acceptors was studied. It was found that when glucose + hexokinase and creatine are present together, the latter accepts almost no phosphate, and the phosphorylation of glucose predominates.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLE METHOD FOR RECORDING ELECTROCORTICOGRAMS IN ANIMALS WITHOUT OPENING THE SKULL

THE following method enables one rapidly to implant electrodes directly in the cortex of small laboratory mammals by the simple method of thrusting Victrola needles through the skull. The needles may then be connected by wires to suitable recording or stimulating apparatus.

Common steel Victrola needles (Fig. 1a) if heated

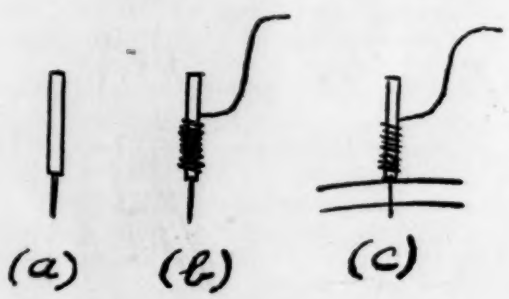

Fig. 1

red in a Bunsen flame for a few seconds lose their brittleness. The needle then is wrapped tightly with fine copper or silver wire from the lower part of its thickened shank to within about 5 mm of its top (Fig. 1b). It is well to let one end of the coiled wire extend for several inches from the shank so that clips connected to the recording apparatus can later grip the wire, thus making a flexible, non-rigid connection which will prevent pull on the implanted electrode. The needle and its wound wire is next dipped into enamel and baked, thus insulating it from subsequent contact with scalp and muscle. The point is scraped bare of enamel for a millimeter or so at the tip, and after sterilizing in alcohol the upper part of the shank is gripped firmly in a simple hand chuck by which the needle can be thrust through the skull.

The scalp and underlying muscles of the skull of the anesthetized animal are separated by a very small sterile incision 5 or 6 mm in length. The head is held firmly in one hand, the incision is spread, and the needle, gripped by the chuck, is thrust firmly through the bone by a straight downwards and rotating thrust. The enlarged shank of the needle stops the point just below the skull surface in the cortical layers (Fig. 1c). Needles thus imbedded are held firmly fast in the bone. The chuck head is carefully unscrewed so as not to loosen the needle in the bone, and the incised tissues are allowed to fall back around the projecting shank which is insulated from them by its enamel coating. A drop of collodion may be applied to the place of entry of the needle. This quickly hardens, helping to brace it and at the same time seal the slight wound from air.

Several dozen of these electrodes can be prepared in an hour and 5 or 6 of them can be implanted in almost as many minutes. When the animal recovers from anesthesia its behavior is normal and the projecting shanks appear to cause no inconvenience. Electrocorticograms recorded from them in unanesthetized rabbits, cats and rats are in all respects identical with those recorded from the exposed cortex. The

method is much to be preferred to recording through skull and scalp by electrodes pasted on the skin. Electrode artifacts, troublesome with this latter type of lead, never appear, localization is precise and the lack of resistance of skull and scalp with the needle, sufficient, in some animals, to make external recording impossible, permits one to record at very low amplification, thus eliminating instability and pick-up artifacts accompanying high amplification. The Victrola needles may be left *in situ* for a considerable period, a thing not possible with those externally applied to the skin.

The leads may be removed without reanesthetizing the animal by simply extracting each one by a firm jerk with a pair of pliers. This extraction appears to be painless. A drop of collodion placed on the small hole rapidly seals it off.

We have kept animals for several days with the leads in place and could have kept them longer. Some 50 electrode insertions have been made in a dozen animals without complications from infection. The electrode positions in the cortex could presumably be precisely determined if one wished in the freshly sacrificed animal by passing an electrolytic (D.C.) current through each lead in turn as cathode, thus producing a deposit of iron oxide at the point of contact with the cortex.

HUDSON HOAGLAND

CLARK UNIVERSITY

AN INEXPENSIVE MOUSE CAGE

IT is often desirable to keep mice in small groups when they are under observation. This requires a number of small cages, which should be easily cleaned, and, if possible, inexpensive. The following cage is suggested for its simplicity, ease of cleaning and cheapness. The materials used are few and obtainable at any hardware store. They are as follows: coarse wire netting, sometimes called hardware cloth, 8 inches × 22 inches, two tin pie plates, 8½ inches in diameter and about 20 inches of 24-gauge soft wire.

The ends of the hardware cloth are brought together to form a cylinder, 6½ inches in diameter. By overlapping the ends one inch and weaving a length of the soft wire in and out through the meshes of the cloth they can be made secure. This is best accomplished by weaving down one side and up the other of the overlapping ends so that the ends of the wire may be brought together near one point and twisted. The cylinder thus made will fit into the bottom of one of the pie plates. The other plate is now placed over the open end of the cylinder, thereby completing the cage.

As many as six mice may be kept in the cage at one time with no danger of them pushing off the top plate. Rats may also be kept in like manner, but it is suggested that a lead weight be soldered on the plate which is used for the cover. The plate used for the bottom should be covered with a piece of 25 cm filter paper, which absorbs moisture and assists the sides of the plate in preventing the scattering of food. To clean the cage the paper is removed and fresh put in its place. The mice will tear the paper to some extent, but if they are well fed this is reduced to a minimum.

A drinking fountain may be made by inserting in a small, wide-mouthed bottle a one-hole rubber stopper fitted with a short length of small bore glass tubing. A bit of rust-resisting wire, such as nichrome, should be fastened in the tube to assist in the flow of water when the mouse is drinking. The fountain should be hung inside the cage by means of a wire sling.

Any other dimensions may be substituted for these suggested so that larger or smaller cages may be made. The total cost of the cage described is about twenty cents, and a half dozen can be made in an hour.

E. WILBUR COOK, JR.

CENTRE COLLEGE

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